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Onion Spraying and Dusting Experiments

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In 1927 and 1928 seed onions died prematurely in the Connecticut Valley of a disease here designated as blast. In earlier years downy mildew of onions, also, sometimes caused a reduction in yields. The experiments here described were undertaken with the object of learning to what extent fungicides will protect onions against these diseases.

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ONION SPRAYING AND DUSTING EXPERIMENTS¹

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Introduction

The field experiments here reported were conducted in 1929, 1930, and 1931, with the object of adding to the knowledge of the effects of Bordeaux mixture (4:4:50 and 8:4:50), milk of lime (4:50), and copper-lime dust on downy mildew of onion (caused by *Peronospora schleideni* Ung.), on the blast disease of onions, and on growth and yields of onions in the absence of these diseases.

Downy Mildew

Downy mildew of onion was general and severe here in 1924, 1925, and 1926. This disease was also reported as present in 1927 and 1928, although it caused little if any loss in those two years.

It has been recommended (2, 14, 6)² that onions be sprayed with Bordeaux mixture for protection against this disease. Such a recommendation is sometimes made with reservations, however, and these seem to be justified by the observation of Knott (10). Writing in 1930 of conditions in New York State, he made the statement that, although a few growers try spraying or dusting onions with a copper fungicide each year, no satisfactory control of downy mildew has thus been obtained.

The disease was, however, found to be preventable or controllable by a copper fungicide in experiments in other States and, presumably, under other conditions. Milbrath (13) has reported that Bordeaux mixture (with a sticker) and also copper-lime dust, showed some promise as tested against downy mildew of onion in California. Similarly, Bordeaux mixture (with a sticker) is reported³ to have given good results in the control of the disease in Colorado; and Dykstra⁴ has informed us that Bordeaux mixture (5:5:50), applied at intervals of 10 to 14 days, satisfactorily controlled downy mildew of onion in small-scale tests in Oregon.

Both Jones (9) and Whetzel (15) observed injury to onion leaves sprayed with Bordeaux mixture. That aspect of the matter is considered subsequently in the present paper; for, in the case of plant diseases such as downy mildew and blast of onion, which do not occur or do not measurably reduce yields (in Massachusetts) every year, the effects of fungicides on the crop in the absence of disease, as well as the cost of spraying, are of especial importance, since there is at present no way of forecasting the probable presence or absence of these diseases, and that would involve spraying every year if at all.

¹ The onion industry in Massachusetts is confined principally to that part of the Connecticut Valley located in Hampshire and Franklin Counties, and the observations and results of experiments recorded in this paper are similarly limited geographically.

² Reference is made by number to "Literature Cited," p. 184.

³ Plant Disease Reporter, Supplement 61. Diseases of vegetable and field crops in the United States in 1927.

⁴ Letter of September 11, 1929, from T. P. Dykstra, Assistant Pathologist, Oregon Agr. Expt. Sta.

Blast

In 1927, 1928, and 1931, seed⁵ onions died prematurely in the Connecticut Valley, although downy mildew was practically or entirely absent, and it was apparent that thrips (*Thrips tabaci* L.), a common cause of the early death of onion leaves, was not responsible. In each of these years, this disease or abnormal condition here designated as blast, first appeared in or about the third week of July when periods of rain were interrupted and followed by high temperatures, bright sunlight, and drying winds.

Macrosporium porri Ell., the pathogenicity of which to onions has been established by Angell (1), *Macrosporium parasiticum* Thum., and Botrytis sp. were often, but by no means always, present on blasting onions.

Onions dying from blast were often found to have pink and decaying roots, and *Phoma terrestris*, which according to Hansen (7) is the true causal agent of the pink-root disease of onions, was isolated by him from onions grown in Massachusetts, which died prematurely in a year of blast. The pink-root disease was, however, no less common in the Connecticut Valley on onions which did not blast, but which died prematurely from other causes, notably thrips and drouth.

These and other considerations indicate, in our opinion, a physiological rather than a parasitic cause of onion blast. The disease did not spread in the sense that plant diseases caused by fungi or bacteria usually spread, as from one part of a field to another; nor was there any apparent relation to differences in soil or topography, soil reaction or previous cropping systems. Whole fields of onions and all fields over a large area, having little if anything in common except climatic environment, began to blast on or about the same day.

While the fungi named, and others, may be contributing factors which hasten the death of blasting onions, our observations and those of other investigators lead us to believe that blast of onion, like tip-burn of potato, has its first cause in the atmospheric conditions indicated above. Lutman (12) has demonstrated that tip-burn of potato is due to too bright sunshine and too high temperatures, and under these same conditions, he observed tip-burn (incipient blast) of onions. Furthermore, onion plants subjected by Jones (8) to conditions of high relative humidity and of light of low intensity, followed by exposure to relatively dry air and to bright sunshine, developed the fading, withering, and dying leaves symptomatic of blast.

In the experiments of Lutman (11) tip-burn of potato was found to be preventable by spraying with Bordeaux mixture, and these experiments with onion were undertaken with the thought that spraying with Bordeaux mixture, or with milk of lime, might be similarly effective in protecting onions against blast. Milk of lime was included, although it is without the fungicidal properties of Bordeaux mixture, for in the experiments of Butler (4) the action of both milk of lime and Bordeaux mixture (4:4:50) on sprayed plants was found to be one of shade.

Methods and Costs

The sprayed plots and their checks were in triplicate and the dusted plots and their checks were in duplicate each year. The treatments of all plots, including materials used, numbers of applications, and intervals of time between applications are recorded in Tables 1, 2, and 3.

⁵ Blast as observed by us was confined almost entirely to seed onions, i.e., onions grown from seed, as distinguished from set onions, i.e., onions grown from sets and harvested earlier.

Copper-lime dust⁶ was applied between 6 and 8 a. m. by means of a hand duster.

Potash fish-oil soap was used as a sticker with the Bordeaux mixtures and with milk of lime at the rate of 3 or 4 pounds to 50 gallons. The sprays adhered well.

It was evident that neither milk of lime nor Bordeaux mixture, even with the addition of fish-oil soap, protected onions against thrips. All plots, including the checks, were therefore sprayed with nicotine sulfate 1:1000, with fish-oil soap 3 or 4 pounds in 50 gallons, as recommended by Bourne (3), often enough to prevent injury by these insects.

Sprays were applied between 6:30 and 9:30 a. m. The spraying, with the exception of the applications made July 30 and August 5 in 1929, was done with the power sprayer which Bourne (*loc. cit.*) has described. With this machine, spray materials were applied at a pressure of 100 to 150 pounds. This outfit was equipped with a spray boom by means of which 6 rows of onions (13 inches apart) were sprayed at one time.

It was necessary to use another power sprayer in 1929 on the two days named above. This involved carrying a hose from the sprayer through the field, and on these dates onions were sprayed by hand, but at a pressure of 200 pounds. This resulted in a much less uniform coverage and the expenditure of more gallons of spray per acre.

At the end of each season, onions were screened to remove those less than $1\frac{1}{4}$ inches in diameter. The yields per acre of onions above this size which were harvested from each plot each year are recorded in Tables 1, 2, and 3 for the years 1929, 1930, and 1931 respectively.

A thorough coverage of the plants, using the power sprayer described by Bourne (*loc. cit.*) required approximately 250 gallons of spray per acre for each application, as an average for the entire season. An acre could be sprayed with this outfit in approximately $1\frac{1}{2}$ hours. This figure represents the time spent in actual spraying and also makes allowance for the necessary refilling.

Estimates of cost of application are based on these figures. No estimates of depreciation of the spray outfit or other items of overhead were included, since these would vary according to the machinery used and could not be figured accurately on an acreage basis.

The cost of four applications of Bordeaux mixture 4:4:50, including labor and materials, was \$19.40 per acre. This included two applications in which nicotine sulfate was added for the control of thrips. The cost of materials alone for the Bordeaux and fish-oil soap combination was \$2.85 per acre for one application. The addition of nicotine sulfate increased the cost to \$5.35 per acre.

On a similar basis, the total cost of six applications of 4:4:50 Bordeaux (including two in which nicotine was added) was \$26.60 per acre.

The 8:4:50 Bordeaux was applied twice (including one application with nicotine) at a total cost of \$12.50 per acre. For three applications in which nicotine was included once, the total cost was \$17.50 per acre. The cost of materials alone for Bordeaux of this strength with fish-oil soap was \$4.25 per acre for each application. The addition of nicotine sulfate raised this figure to \$6.75 per acre.

Milk of lime was applied six times (including two applications with nicotine) at a total cost of \$18.20 per acre.

In every case, potash fish-oil soap was added to the Bordeaux mixture and milk of lime to increase the adhesiveness of the spray and give more uniform

⁶ Guaranteed to contain not less than 19% monohydrated copper sulfate and not over 81% inert ingredients.

coverage. This represented a cost of \$1.05 per acre for each application.

The most expensive item in each combination was the nicotine sulfate which added approximately \$2.50 per acre to the cost of each application. Since Bordeaux or lime alone, however, proved no deterrent for thrips, the addition of nicotine sulfate was necessary.

Results in 1929

The season of 1929 was very dry. Some drouth injury occurred, but neither blast nor downy mildew was observed in this season.

Eight applications of copper-lime dust applied at weekly intervals, beginning July 1, resulted in decreases in yields of from 23.6 to 30.2 per cent. Yields were decreased rather more by six applications of copper-lime dust applied weekly, beginning July 22. In the absence of disease and under the weather conditions prevailing in 1929, copper-lime dust as applied was injurious to onions.

Leaves were rather severely injured by Bordeaux mixture 4:4:50 and by Bordeaux mixture 8:4:50 applied twice by hand, as described above. Milk of lime similarly applied was not markedly injurious. This injury is attributed more to the over-spraying and uneven coverage than to Bordeaux mixture itself; for in the case of early applications and applications in the two following years, made at a pressure of 100 to 150 pounds with the field sprayer (3), no injury by Bordeaux mixture was observed.

With no disease present and with spray injury apparent, it is not surprising to note (see Table 1) that decreased yields resulted in all plots sprayed with Bordeaux mixture. Bordeaux mixture 4:4:50 applied eight times at intervals of two weeks, beginning July 1, or Bordeaux mixture 8:4:50 applied 5 times at intervals of two weeks, were most injurious, resulting in reductions in yield of from 26.0 to 34.7 per cent. The injury following six applications of Bordeaux mixture 4:4:50, made at weekly intervals, beginning July 22, was much less; the reductions in yields in this case were from 1.6 to 11.9 per cent.

In two plots sprayed with milk of lime, there were small increases (7.4 per cent) in yield, but in the third plot thus treated, a decrease in yield resulted.

It is evident from this that Bordeaux mixture applied by hand and at too high a pressure, injured onions, and that this injury, with diseases absent, more than offset any possible beneficial effect of spraying.

Results in 1930

Yields (see Table 2) were low in 1930, although in 1930 as in 1929, neither blast nor downy mildew was present.

Yields were neither increased nor decreased consistently and significantly by copper-lime dust applied four times or six times at weekly intervals.

Six applications of milk of lime at weekly intervals resulted in decreases in yields of 4.9 and 10.2 per cent in two plots and an increase of 3.9 per cent in the other plot. The mean yield in plots sprayed with milk of lime was decreased by 3.9 per cent.

The effect of Bordeaux mixture, while not uniform in all plots, was in general beneficial. Increases in mean yields resulted in all cases, with the largest increase, 19.5 per cent, in the plots sprayed six times with Bordeaux mixture 4:4:50 or twice with Bordeaux mixture 8:4:50. Smaller increases (14.3 per cent) in mean

TABLE 1.—YIELDS OF ONIONS IN 1929.

TREATMENTS				NUMBER OF 100 LB. SACKS PER ACRE				PERCENTAGE INCREASE OR DECREASE IN YIELD *			
Material	Number of applications	Date begun	Interval (weeks)	Series 1	Series 2	Series 3	Mean	Series 1	Series 2	Series 3	Mean
No treatment (check for sprayed plots)				258	202	250	237				
Bordeaux mixture 4:4:50	8	July 1	1	186	136	177	166	-27.9	-32.7	-29.2	-30.0
Bordeaux mixture 4:4:50	6	July 22	1	228	178	246	217	-11.6	-11.9	-1.6	-8.4
Bordeaux mixture 8:4:50	5	July 1	2	191	132	178	167	-26.0	-34.7	-28.8	-29.5
Bordeaux mixture 8:4:50	3	July 22	2	221	179	221	207	-14.3	-11.4	-11.6	-12.6
Milk of lime 4:50	8	July 1	1	226	141	223	196	-12.4	-30.2	-10.8	-17.3
Milk of lime 4:50	6	July 22	1	277	217	206	233	+7.4	+7.4	-17.6	-1.7
No treatment (check for dusted plots)				149	89	...	119				
Copper-lime dust	8	July 1	1	104	68	...	86	-30.2	-23.6		-27.7
Copper-lime dust	6	July 22	1	96	52	...	74	-35.6	-41.6		-37.8

TABLE 2.—YIELDS OF ONIONS IN 1930.

No treatment (check for sprayed plots)				122	51	59	77				
Bordeaux mixture 4:4:50	6	July 14	1	132	92	51	92	+8.2	+80.4	-13.6	+19.5
Bordeaux mixture 4:4:50	4	July 28	1	138	74	53	88	+13.1	+45.1	-10.2	+14.3
Bordeaux mixture 8:4:50	3	July 14	2	154	53	56	88	+26.2	+3.9	-5.1	+14.3
Bordeaux mixture 8:4:50	2	July 28	2	145	68	62	92	+18.8	+33.3	+5.1	+19.5
Milk of lime 4:50	6	July 14	1	116	53	53	74	-4.9	+3.9	-10.2	-3.9

No treatment (check for dusted plots).....	221	255	...	238			
Copper-lime dust.....	6	July 14	1	249	253	...	251
Copper-lime dust.....	4	July 28	1	249	227	...	238
						+12.7	-0.8
						+12.7	-11.0
							+5.5
							0.0

TABLE 3.—YIELDS OF ONIONS IN 1931.

No treatment (check for sprayed plots).....	164	97	97	119			
Bordeaux mixture 4:4:50.....	6	July 13	1	168	137	110	138
Bordeaux mixture 4:4:50.....	4	July 27	1	181	124	121	142
Bordeaux mixture 8:4:50.....	3	July 13	2	166	114	87	122
Bordeaux mixture 8:4:50.....	2	July 27	2	170	118	108	132
Milk of lime 4:50.....	6	July 13	1	170	102	126	133
						+2.4	+41.2
						+10.4	+27.8
						+1.2	+17.5
						+3.7	+21.6
						+3.7	+5.2
No treatment (check for dusted plots).....	139	127	...	133			
Copper-lime dust.....	6	July 13	1	108	76	...	92
Copper-lime dust.....	4	July 27	1	119	111	...	115
						-22.3	-40.2
						-14.4	-12.6
							-30.8
							-13.5

* An increase is indicated by the plus sign (+); a decrease by the minus sign (-).

yields resulted in the plots sprayed four times with Bordeaux mixture 4:4:50 or three times with Bordeaux mixture 8:4:50. In only one series of plots were decreased yields associated with these treatments.

It is evident from this that yields of onions may be increased somewhat by Bordeaux mixture applied uniformly and at not too high a pressure, even in years of no downy mildew and no blast. Such an effect is tentatively attributable to a direct stimulation or to protection against fungi which are usually of minor importance. Increases in yields were, however, too small on the whole to indicate that spraying would be a profitable practice with neither blast nor downy mildew present.

Results in 1931

There was no downy mildew in 1931, but blast was severe, appearing, as in 1927 and 1928, about the third week of July.

It was evident by the first of August that onions sprayed with Bordeaux mixture were blasting less and more slowly than were onions not so sprayed. But the appearance of blast, although delayed, was not entirely prevented by Bordeaux mixture, and the increases in yields following spraying with Bordeaux mixture were not large. Yields were, however, increased somewhat in all plots sprayed with Bordeaux mixture 4:4:50, and in all but one of the six plots sprayed with Bordeaux mixture 8:4:50.

Six applications of Bordeaux mixture 4:4:50 were followed by increases in yields of from 2.4 to 41.2 per cent, but the increase in the mean yield of the three plots (16.8 per cent) was no larger than that associated with the corresponding treatment in 1930, when there was no blast. The most consistent and, on the whole, the largest increases in yields (with a mean of 19.3 per cent) were in those plots sprayed four times with Bordeaux mixture 4:4:50, but even in this case, the increases in yields were not much more than those which followed a corresponding treatment in 1930 with blast absent.

Two applications of Bordeaux mixture 8:4:50 were of more benefit than three applications of this fungicide, but increases in yield resulting from the former were smaller in this year of blast than in the previous year when that disease was absent.

Our conclusion, on the basis of the results in 1931, is that increases in yields resulting from spraying with Bordeaux mixture in a year of blast were not sufficiently large and consistent to indicate that the practice would be profitable under present conditions.

Yields were increased 3.7 to 29.9 per cent in the plots sprayed with milk of lime. These increases in yield in the presence of blast were, on the whole, larger than in the two previous years when blast was absent; but increases were small in two out of three plots. Milk of lime, on the whole, was of less benefit in both 1930 and 1931 than Bordeaux mixture, indicating that at least part of the benefit of the Bordeaux mixture was probably due to its superior fungicidal properties.

As in previous years, copper-lime dust was of no benefit. The onset of blast was not measurably retarded by it, and yields were lower in all plots to which copper-lime dust was applied. The decreases in yields in dusted plots were larger following five than following three applications.

Discussion and Conclusions

The absence of downy mildew in 1929, 1930, and 1931 made it impossible, of course, to add to the knowledge concerning the efficacy and practicality of

spraying and dusting with copper fungicides, for the prevention of this disease. But downy mildew does not cause loss in Massachusetts often enough or seriously enough to warrant spraying onions every year, unless it can be shown that increased yields would much more than pay for the cost of spraying in years when there is no downy mildew, and especially in years when blast occurs. We are now in a position to comment further on the effects of copper fungicides on onions under the conditions indicated above.

Copper-lime dust as used, resulted in injury to onions sufficient to more than offset any possible fungicidal value. In no year was it of any real or consistent benefit, and in two years, including a year of blast, it was definitely injurious and much more injurious than the same number of applications of Bordeaux mixture. Yields of onions in a year of blast were increased by Bordeaux mixture, but not by copper-lime dust. In this response, blast of onions again showed some similarity to tip-burn of potato, for in the experiments of Butler (5) copper-lime dust was much inferior to Bordeaux mixture in reducing injury of potatoes due to tip-burn.

Onions were not injured by Bordeaux mixture 4:4:50 or even 8:4:50 applied with suitable machinery at a pressure of 100 to 150 pounds, although it was injurious when applied by hand and in too large amounts at a pressure of 200 pounds. With the object of reducing the total cost of applications, Bordeaux mixture 8:4:50 was applied only half as often as was Bordeaux mixture 4:4:50. In the absence of blast, yields were increased about as much by Bordeaux 8:4:50 applied at intervals of two weeks as by Bordeaux mixture 4:4:50 applied weekly, and at less cost. Neither treatment, however, gave significantly increased yields with enough consistency to prove that spraying onions with a copper fungicide would be a profitable operation in years of no blast and no downy mildew. In a year of blast (1931), yields were increased more by Bordeaux mixture 4:4:50 applied weekly than by Bordeaux mixture 8:4:50 applied at intervals of two weeks.

Bordeaux mixture of both concentrations delayed the onset of blast, as it is known to delay the appearance of tip-burn of potato. Four weekly applications of Bordeaux mixture 4:4:50, begun July 27, just before blast occurred, were followed by the largest and most consistent increases in yield, and this is the concentration and schedule preferred should a grower wish to attempt protection against blast by spraying. Blast occurred in only one year out of the three in which these experiments were conducted and the increases in yield which resulted from this treatment were not, in our opinion, great enough to warrant the recommendation that onions be sprayed every year for protection against blast.

Increases in yield following the use of milk of lime were even smaller, and Bordeaux mixture is certainly to be preferred to it. But in a year of blast, yields were increased a little by milk of lime, this increase (for the mean) being greater than in years of no blast.

It has been established (3) that, in spite of certain practical difficulties involved, onions may be successfully protected against thrips by spraying two or three times in a season with a nicotine sulfate-fish-oil soap combination. But a satisfactory power sprayer for such a crop is relatively expensive and onions have not often been sprayed in the past to prevent injury by thrips. Growers who, individually or jointly, find the ownership of a power sprayer feasible, and who spray onions for protection against thrips may, on the basis of the results of our experiments, expect some further increase in yield if Bordeaux mixture 4:4:50 is used with nicotine sulfate. But the data as presented above do not

indicate that the purchase and use of a power sprayer solely for the application of Bordeaux mixture to onions would be profitable in the average year in Massachusetts. Since Bordeaux mixture, nicotine sulfate, and fish-oil soap are compatible and since the cost of spraying is not materially increased (only \$1.80 per acre per application) by the inclusion of Bordeaux mixture 4:4:50 in this combination, it is suggested that these materials be used when spraying to prevent injury to onions by thrips.

Summary

Onions were injured by copper-lime dust in two out of three years, and loss caused by blast was not lessened by this treatment.

Bordeaux mixtures 4:4:50 and 8:4:50 were not injurious to onions when applied with a suitable power sprayer and at a pressure of 100 to 150 pounds.

In the absence of downy mildew and blast, yields of onions were increased somewhat by spraying with Bordeaux mixture.

Milk of lime was less effective.

The onset of blast was delayed, but not prevented by Bordeaux mixture. In a year of blast, yields of onions were increased the most by four weekly applications of Bordeaux mixture 4:4:50.

Increases in yield resulting from this treatment were not large enough to justify spraying onions every year with a copper fungicide alone under Massachusetts conditions, since downy mildew and blast are not present here every year.

It is suggested, however, that growers spraying onions with nicotine sulfate for protection against thrips include Bordeaux mixture in the combination spray.

Literature Cited

1. ANGELL, H. R.
1929. Purple blotch of onions (*Macrosporium porri* Ell.). Jour. Agr. Research 38:467-487, illus.
2. BEATTY, W. R.
1915. Onion culture. U. S. Dept. Agr. Farmers' Bul. 354, 36 p., illus.
3. BOURNE, A. I.
1929. Spraying for the control of onion thrips. Jour. Econ. Ent. 22:679-683, illus.
4. BUTLER, O.
1922. Bordeaux mixture II. Stimulatory action. N. H. Agr. Expt. Sta. Tech. Bul. 21, 50 p.
5. —————
1927. Hand spraying and hand dusting potatoes. N. H. Agr. Expt. Sta. Circ. 26, 16 p., illus.
6. CHUPP, CHARLES.
1925. Manual of vegetable-garden diseases. 647 p., illus. New York.
7. HANSEN, H. N.
1929. Etiology of the pink-root disease of onions. Phytopath. 19:691-704, illus.

8. JONES, L. H.
1930. Onion blast. (p. 343 in the Annual Report for the fiscal year ending November 30, 1929.) Mass. Agr. Expt. Sta. Bul. 260.
9. JONES, L. R.
1897. The onion mildew. (Report of Botanist, pp. 61-62.) Vt. Agr. Expt. Sta. Ann. Rpt. 10 (1896-97).
10. KNOTT, J. E.
1930. Growing onions on the muck soils of New York. N. Y. (Cornell) Agr. Expt. Sta. Bul. 510, 34 p., illus.
11. LUTMAN, B. F.
1916. Some studies on Bordeaux mixture. Vt. Agr. Expt. Sta. Bul. 196, 80 p., illus.
12. —————
1919. Tip-burn of the potato and other plants. Vt. Agr. Expt. Sta. Bul. 214, 28 p., illus.
13. MILBRATH, D. G.
1926. Plant pathology. Calif. Dept. Agr. Mo. Bul. 15. (pp. 131-133.)
15. WALKER, J. C.
1931. Onion diseases and their control. U. S. Dept. Agr. Farmers' Bul. 1060, 24 pp., illus.
15. WHETZEL, H. H.
1904. Onion blight. N. Y. (Cornell) Agr. Expt. Sta. Bul. 218:137-161, illus.

